Quarterly Progress Report

For the project entitled:

Inhibitor Longevity and Deicer Performance

Reporting Period: October 16, 2008 – Jan. 15, 2009

Prepared by

Laura Fay, M.Sc.

Research Scientist / Co-Principal Investigator

and

Xianming Shi, Ph.D., P.E.

Program Manager / Principal Investigator

Winter Maintenance and Effects Program
Western Transportation Institute (WTI)
College of Engineering
Montana State University – Bozeman

Submitted to:

Research Office
Washington State Department of Transportation
Transportation Building, MS 47372
Olympia, Washington 98504-7372

and the
Pacific Northwest Snowfighters Association
Transportation Pooled Fund TPF-5(035)

January 23, 2009

Task 0: Project Management

Weekly meetings were held between team members and the Principal Investigators. As a result of these meetings, experimental design, planning issues, laboratory methods, and items for the field investigation were discussed so that testing was conducted in a timely manner.

Personnel updates include the increased role of Mr. Doug Cross in Task 3 (Field Investigation) and Mrs. Marijean Peterson in Task 2 (Laboratory Investigation). An undergraduate research student has been funded through the WTI-URE fellowship program to participate in the lab portion of this research project.

Task 1: Experimental Design and Planning (65%)

Planning for Task 3.1

The final product to be tested in the field is IceSlicer Elite, was decided upon and has been delivered to the site. The original confidentiality agreement remains in effect for the product despite the slight modification to the product.

Modifications are being made to the field site to winterize the equipment, to prevent snow drifts from limiting site access, and to cover the open side of the buildings in order to prevent precipitation from reaching the solid material piles. In addition, a side experiment with MDT Research Branch has been started and will closely monitor weather parameters, precipitation and evaporation rates, and moisture flow into the outside deicer pile cisterns. This will replace the small-scale collection pad that was discussed at the site visit.

Planning for Task 3.2

Liquid and solid application equipment has been purchased and set up on a tow trailer. Base on Steering Committee feedback we will use spray liquid applicator nozzles. We have tested the spray liquid applicator nozzles in the laboratory and will use the spray nozzles for field application of the liquid deicers. The application equipment allows us to

apply small quantities (to be specified by the Steering Committee and TAC, ***please advise on the application rate of liquid and solid materials***) of deicer products for the field operational tests with precision in application rate. Testing of the liquid and solid application equipment has begun and will be finalized this quarter (Winter/Spring of 2009) to ensure we can reproduce the application rate and recover the material applied. A test run of equipment and sampling is planned to occur in February 2009.

Standard operating procedures (SOPs) are being developed for the simulation of each storm event identified (creating "artificial" storms), the application of deicers (liquid and solid) on pavement, and the collection of deicer samples from the field pavement. The SOPs are designed to minimize the uncertainties and risks in the field investigation.

Transcend

- We are working closely with the *Transcend* team at WTI (including Eli Cuelho, Michelle Akin, and Jason Harwood) to ensure the success of this project. The current date for the power, water, and snow-making equipment to be in place and operational at *Transcend* is January 19, 2009.

- The building at *Transcend* will be in place by the end of January 2009.

- Surface pavement temperature sensors have been installed on the asphalt pad where testing will be conducted, and soil temperature sensors have been installed to a depth of 17 inches.

Task 2: Laboratory Investigation (60%)

Task 2.1: Method to Rapidly Quantify Inhibitor Concentrations (90%)

UV-Vis

The ultraviolet-visible spectroscopy or spectrophotometry (UV-vis) is routinely used in the quantitative determination of solutions of transition metal ions and highly conjugated organic compounds. Organic compounds, especially those with a high degree of conjugation, also absorb light in the UV or visible regions of the electromagnetic spectrum. The research team is identifying the characteristic UV-absorption peak for each of the selected corrosion inhibitors. Figure 2.1 shows the characteristic UV-

absorption peak for Freezeguard CI Plus at varying concentrations. The characteristic UV-absorption peak of each corrosion inhibitor was determined and ranged between 260-275nm. A standard curve was then made which correlated the inhibitor concentration with the UV signal intensity.

Figure 2.1 UV-vis analyses of varying concentrations of Freezeguard CI Plus corrosion inhibitor.
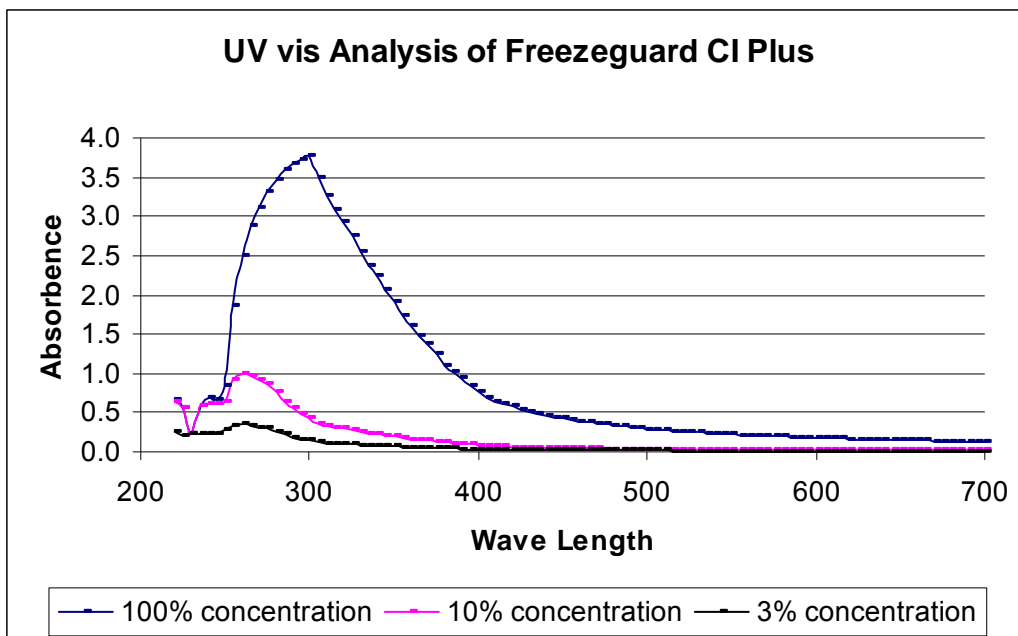
For each corrosion inhibitor of interest, the research team prepared standard solutions with known inhibitor concentrations using de-ionized water as the solvent and analyzed the standards with UV-vis spectrophotometer. The presence of the inhibitor gives a response (e.g. optical density) proportional to the concentration. As such, a standard calibration curve was established for each inhibitor. Figure 2.2 (a-c) shows the standard calibration curve for Freezeguard CI Plus corrosion inhibitor (R^2=0.91), Geomelt C corrosion inhibitor (R^2=0.99), and GLT corrosion inhibitor (R^2=0.99), respectively. For any field samples with unknown inhibitor concentration, the measured UV-vis absorbance of the sample was compared against the calibration curve to derive the inhibitor concentration.

Figure 2.2 UV-vis standard curves showing the analysis of varying concentrations of a) Freezeguard CI Plus corrosion inhibitor, b) Geomelt C corrosion inhibitor, and c) GLT corrosion inhibitor.
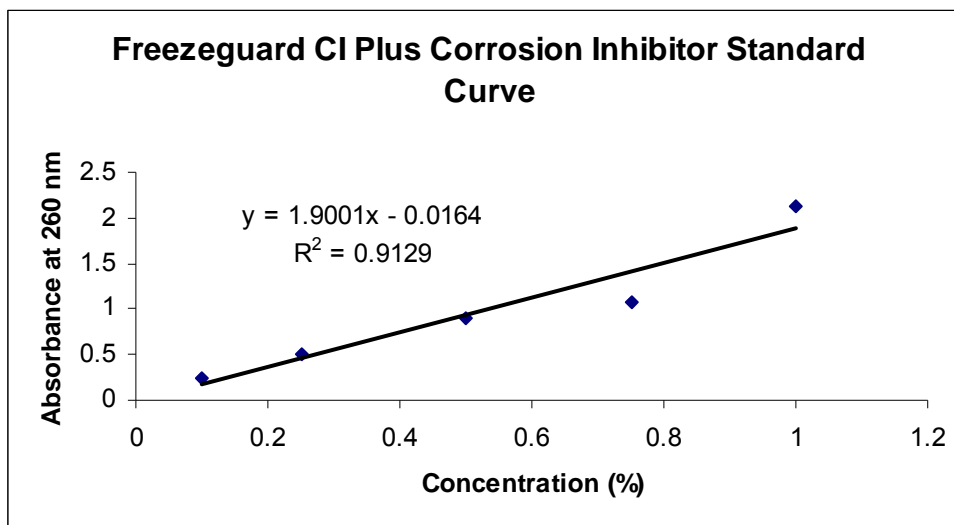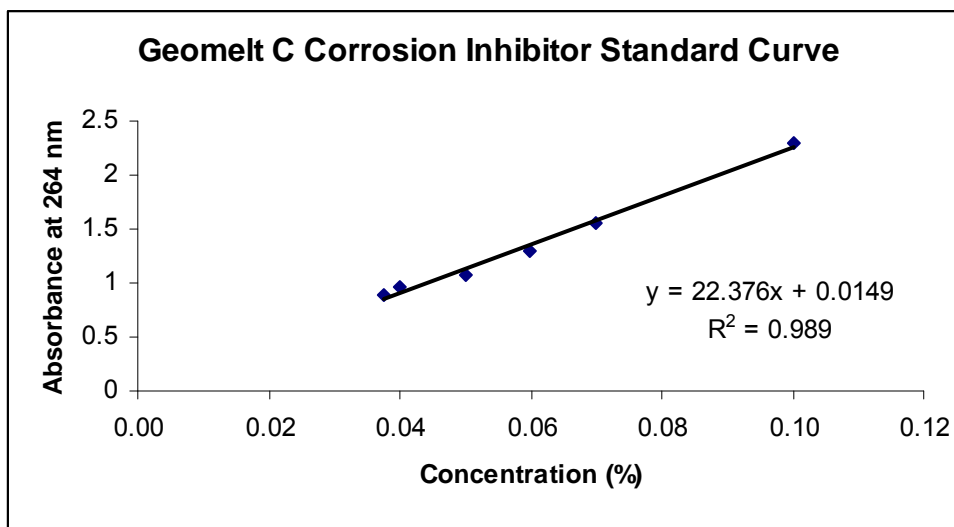

Freezeguard CI Plus Corrosion Inhibitor Standard Curve

$y = 1.9001x - 0.0164$
$R^2 = 0.9129$

Figure 2.2 (a)

Geomelt C Corrosion Inhibitor Standard Curve

$y = 22.376x + 0.0149$
$R^2 = 0.989$

Figure 2.2 (b)

GLT Standard Curve
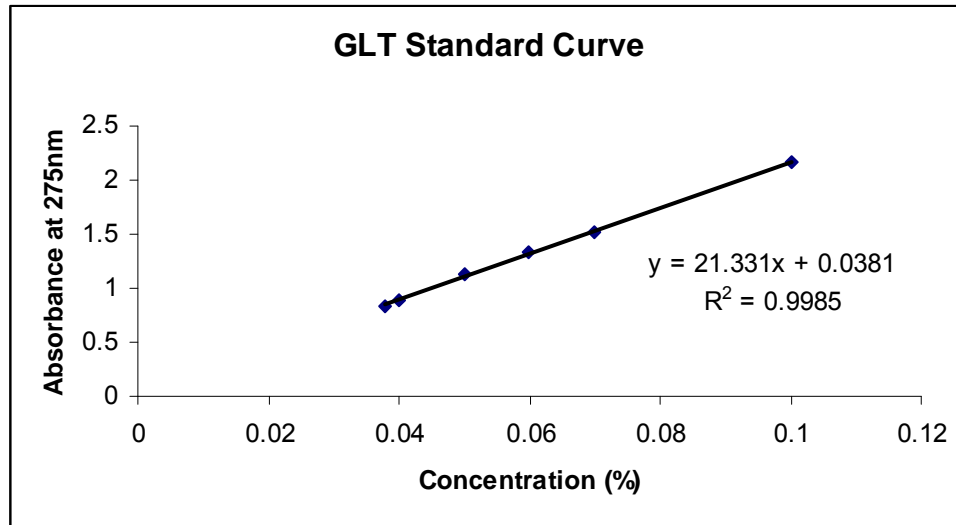
$y = 21.331x + 0.0381$
$R^2 = 0.9985$

Figure 2.2. (c)

Chloride Concentration of Deicers

The chloride concentration of all samples was determined with a chloride ion selective probe (WQ-CL Smart USB Chloride Sensor, Nexsens Technology). See Task 3.1 for chloride concentration data.

pH of Deicers

The pH of the deicers was measured using an AB15 pH meter (Accumet, Fisher Scientific). Figure 2.3 shows the change in pH of the three liquid deicers over time.

Figure 2.3 Measured pH of deicer solutions over time.
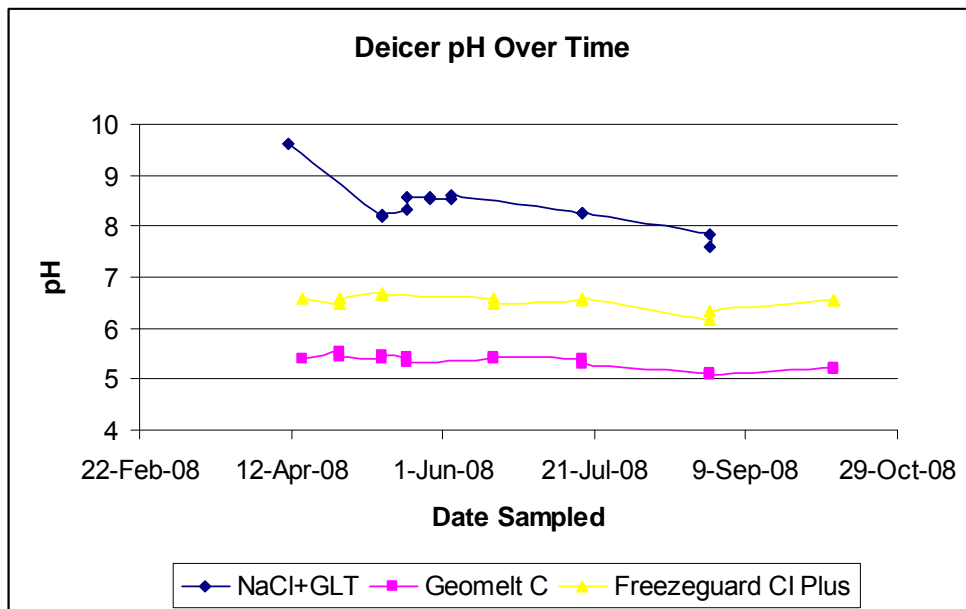
Task 2.2.: Method to Rapidly Quantify Corrosivity of Deicers (90%)

PNS/NACE Corrosion Test

The PNS/NACE test is based on a gravimetric method that entails cyclic immersion of multiple parallel coupons for 72 hours on a custom designed machine. The weight loss result in MPY (milli-inch per year) is translated into a percentage, or percent corrosion rate (PCR), in terms of the solution corrosivity relative to a eutectic salt brine. Testing with the Corrosion Testing Machine (Ad-Tek, Inc) as specified in the PNS/NACE modified gravimetric test has begun. Figures 2.4-2.6 show the measured weight loss results in percent corrosion rate (PCR). The standard deviation for samples run to date is 1.24.

Samples run to date reveal that the NaCl+GLT deicer has an increasing corrosion rate starting in September 2008 causing borderline to failing corrosion scores thereafter. All samples from September 2008 to present are being rerun to validate this trend. The observed increase in corrosion rate will also be compared with the electrochemistry corrosion rate data and the UV-vis corrosion inhibitor concentration data to determine if the corrosion inhibitor is degrading or if there is an error with the test method. The

Freezeguard CI Plus deicer corrosion rate data shows a slight increase in corrosion rate over time as well, but to a much lesser extent than observed with the NaCl+GLT. The Geomelt C corrosion rate does not show any increase over time. Observed fluctuations in the deicer corrosivity over time may have been caused by the deicer sampling process.

Figure 2.4 PNS/NACE cyclic emersion corrosion test results for NaCl+5% GLT, where *m* represents samples mixed in the field and ***nm*** represents samples not mixed.
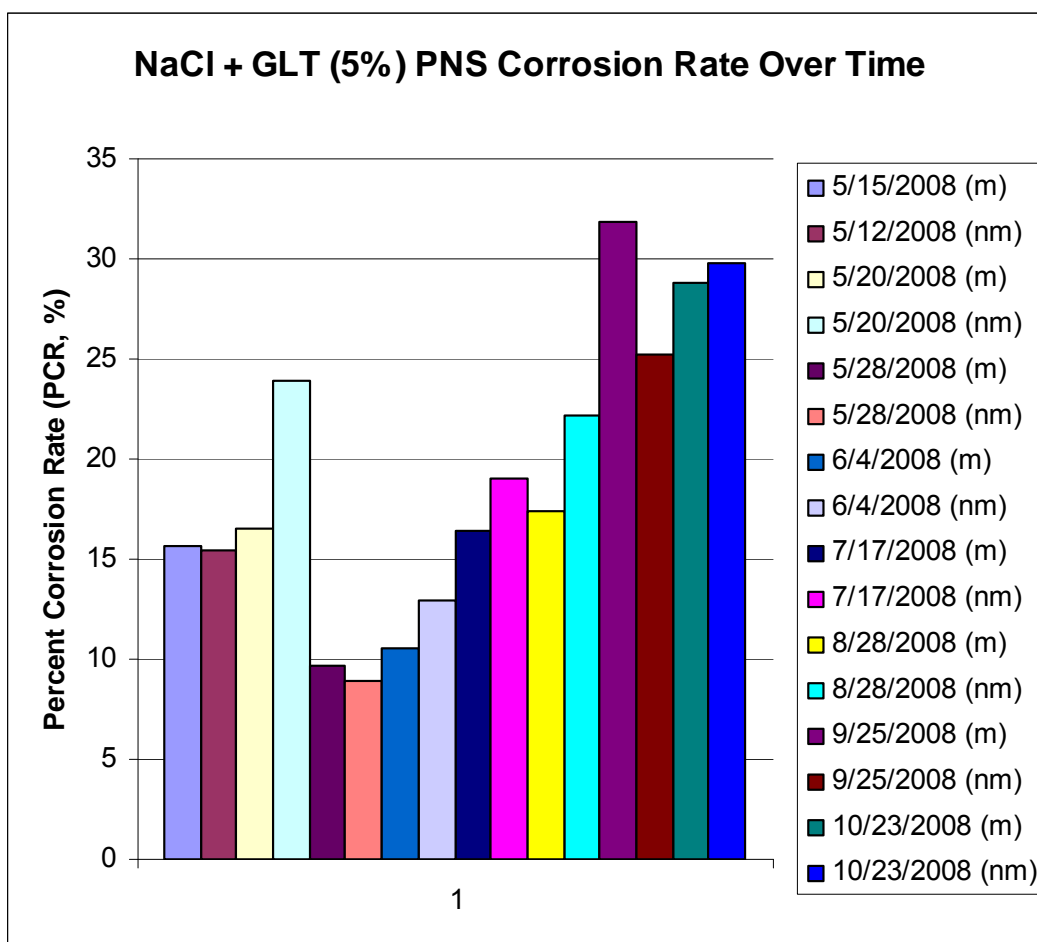
Figure 2.5 PNS/NACE cyclic emersion corrosion test results for Freezeguard CI Plus, where **m** represents samples mixed in the field and **nm** represents samples not mixed.
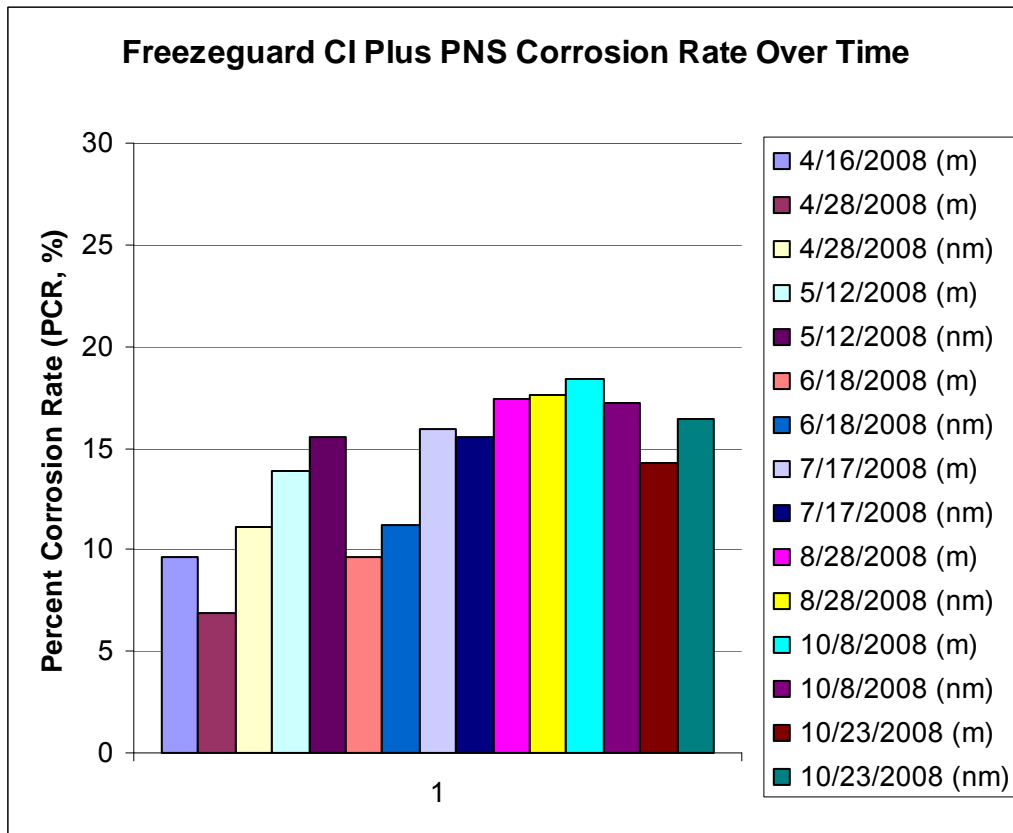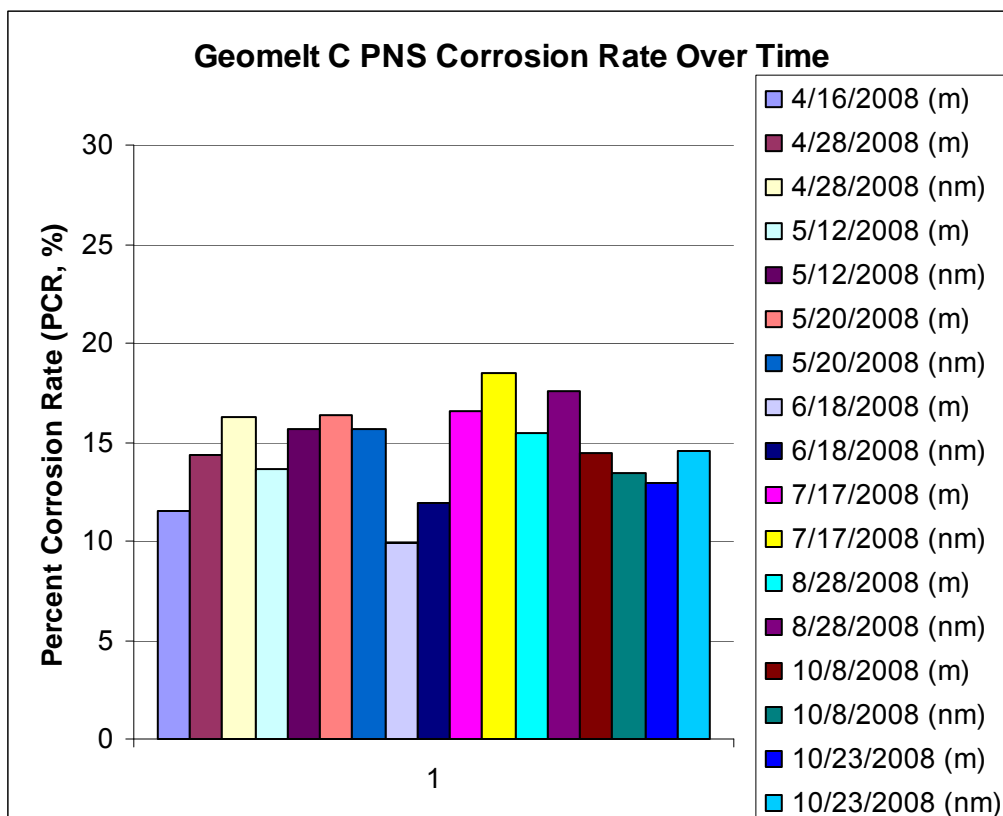
Figure 2.6 PNS/NACE cyclic emersion corrosion test results for Geomelt C, where *m* represents samples mixed in the field and *nm* represents samples not mixed.

Electrochemical Measurements

Electrochemical techniques to determine deicer corrosivity to metals provides an alternative to the gravimetric method in terms of allowing for the rapid determination of corrosion rate of metals and revealing information pertinent to the corrosion mechanism and kinetics.

The electrochemical technique was able to rapidly (within 3 hours) evaluate the corrosivity of deicer products with or without corrosion inhibitors. Liquid samples collected to date have been tested with mild steel coupons (ASTM A36) using the electrochemical techniques. Table 2.1 shows some of the electrochemical data collected.

Table 2.1 Electrochemical data collected for deicers samples.

Freezeguard CI Plus		Corrosion Rate (MPY)	Impedence (Kohm cm^2)	Ecorr (mV, SCE)	Icor (μA/cm^2)
5/12/2008	mixed	22.6	0.36	-866.8	49.4
5/12/2008	not mixed	31.5	0.32	-878.6	69
6/18/2008	mixed	77.6	0.15	-870.4	169.8
6/18/2008	not mixed	36.0	0.30	-864.5	78.7
7/17/2008	mixed	42.5	0.27	-871.8	92.9

Geomelt C		Corrosion Rate (MPY)	Impedence (Kohm cm^2)	Ecorr (mV, SCE)	Icor (μA/cm^2)
5/12/2008	mixed	51.0	0.16	-764.2	111.7
5/12/2008	not mixed	56.5	0.17	-810.2	123.7
5/20/2008	mixed	44.0	0.20	-739.6	96.4
5/20/2008	not mixed	80.1	0.10	-748.3	175.4
6/18/2008	mixed	51.9	0.13	-712.0	113.6
6/18/2008	not mixed	13.8	1.10	-901.7	30.1
7/17/2008	mixed	26.7	0.30	-763.3	58.4
7/17/2008	not mixed	24.6	0.33	-762.4	54.3

NaCl+GLT		Corrosion Rate (MPY)	Impedence (Kohm cm^2)	Ecorr (mV, SCE)	Icor (μA/cm^2)
5/12/2008	mixed	13.5	1.10	-814.1	29.6
5/12/2008	not mixed	132.4	0.17	-844.9	289.8
5/20/2008	mixed	24.9	0.64	-825.5	54.4
5/28/2008	not mixed	47.2	0.53	-941.4	103.4
6/4/2008	mixed	64.5	0.38	-821.1	141.2
7/17/2008	mixed	43.2	0.49	-854.5	94.5
7/17/2008	not mixed	45.0	0.49	-910.0	98.4

The preliminary corrosion data of mild steel shows a weak correlation between the electrochemical data (E_{corr} and i_{corr}) and the PCR data collected using the PNS/NACE corrosion test. However, more data points are needed before we can make a definitive conclusion. The original goal of this test was to establish a standard curve to correlate their corrosivity in PCR as a function of E_{corr} and i_{corr} for each deicer product. Then, for each type of deicer, a second standard curve will be established to correlate its E_{corr} and i_{corr} as a function of chloride and inhibitor concentrations. If such strong correlations do not exist, the electrochemical test can still be used as a QA/AC tool to detect any contamination or quality issues of the deicer product.

Task 2.3.: Method to Rapidly Quantify Deicer Performance (90%)

DSC Measurements

This task involves establishing a method to rapidly quantify deicer performance using a differential scanning calorimetry (DSC) thermogram instead of eutectic curve. DSC is an experimental technique that measures the energy necessary to maintain a near-zero temperature difference between the test substance and an inert reference material, with the two subjected to an identical (heating, cooling or constant) temperature program. By measuring the heat flow, DSC can detect phase transitions, quantify energy change, and measure kinetics of the transitions. DSC measurements typically require only a few milligrams of the sample, which is sealed in an aluminum capsule.

The eutectic temperature of a deicer is the temperature at which crystallization completes and the product becomes solid. A deicer featuring lower eutectic temperature does not necessarily have lower effective temperature or higher ice melting capacity. Therefore, we argue that the DSC thermogram provides a much better indication of the deicer performance than the widely-used eutectic curve (eutectic temperature as a function of deicer concentration). In fact, based on the DSC thermograms of a deicer at different concentrations, one can generate a more useful curve of effective temperature vs. deicer concentration, or even predicted ice melting capacity vs. deicer concentration.

Overall, the DSC thermogram provides useful information in regard to the thermodynamics of the deicer solution, which will provide insight into its freezing/thawing behavior in the absence of pavement. For instance, the characteristic temperature shown in Table 2.2 is a much more reliable indicator of the starting point of ice crystal growth than the eutectic temperature, which should correspond to the formation of slippery conditions on pavement, or the "effective temperature" of the deicer applied.

Table 2.2 DSC data collected for deicer samples being monitored under storage

Sample		Date Collected	Characteristic Temperature			Heat Flow (J/g)	
			Average (°C)	Stdev	Average (°F)	Average	Stdev
Freezeguard CI Plus	mixed	4/16/2008	-13.5	0.7	7.7	72.3	5.3
Freezeguard CI Plus	mixed	4/28/2008	-12.0	0.4	10.4	105.4	9.0
Freezeguard CI Plus	not mixed	4/28/2008	-12.5	0.3	9.5	108.8	8.0
Freezeguard CI Plus	mixed	5/12/2008	-12.2	1.5	10.0	80.2	9.0
Freezeguard CI Plus	not mixed	5/12/2008	-12.3	1.6	9.9	91.3	19.5
Freezeguard CI Plus	mixed	6/18/2008	-12.1	0.1	10.2	113.5	6.6
Freezeguard CI Plus	not mixed	6/18/2008	-12.7	0.4	9.1	98.6	7.8
Freezeguard CI Plus	mixed	7/17/2008	-11.6	0.5	11.1	98.1	23.4
Freezeguard CI Plus	not mixed	7/17/2008	-12.2	0.2	10.0	79.3	20.5
NaCl+GLT	mixed	5/12/2008	-2.5	0.1	27.5	235.0	9.0
NaCl+GLT	not mixed	5/12/2008	-2.8	0.2	27.0	187.9	74.6
NaCl+GLT	mixed	5/20/2008	-2.6	0.2	27.3	231.2	27.2
NaCl+GLT	not mixed	5/20/2008	-6.2	0.1	20.8	150.9	2.7
NaCl+GLT	mixed	5/28/2008	-3.1	0.4	26.4	216.0	12.5
NaCl+GLT	not mixed	5/28/2008	-2.6	0.1	27.3	232.6	21.4
NaCl+GLT	mixed	6/4/2008	-3.4	0.3	25.9	215.5	5.0
NaCl+GLT	not mixed	6/4/2008	-2.4	0.2	27.7	248.8	8.2
NaCl+GLT	mixed	7/17/2008	-5.4	1.1	22.3	114.2	76.9
NaCl+GLT	not mixed	7/17/2008	-6.9	0.1	19.6	134.9	5.7
Geomelt C	mixed	4/16/2008	-12.1	0.1	10.3	110.7	12.5
Geomelt C	mixed	4/28/2008	-14.7	1.8	5.5	84.7	6.2
Geomelt C	not mixed	4/28/2008	-12.6	1.8	9.3	98.3	12.9
Geomelt C	mixed	5/12/2008	-12.4	1.3	9.7	113.3	18.4
Geomelt C	not mixed	5/12/2008	-12.0	0.4	10.4	119.8	8.0
Geomelt C	mixed	5/20/2008	-12.6	1.2	9.3	111.9	4.5
Geomelt C	not mixed	5/20/2008	-12.0	0.9	10.4	109.9	9.8
Geomelt C	mixed	6/18/2008	-11.1	0.4	12.0	125.8	5.2
Geomelt C	not mixed	6/18/2008	-12.4	1.3	9.7	113.5	9.6
Geomelt C	mixed	7/17/2008	-10.4	0.3	13.3	128.1	7.0
Geomelt C	not mixed	7/17/2008	-11.6	0.6	11.1	101.3	12.0

From recent efforts in another WTI project, we found a very reasonable correlation between heat flow (from DSC output, as shown in Table 2.2) and ice melting capacity (from SHRP tests at 32°F (0°C) after 60 minutes). The following preliminary results have been detailed in: [Fay, L., Shi, X., Volkening, K., Peterson, M.M. Laboratory Evaluation of Alternative Deicers: The Path to Decision-Making Based on Science and Agency Priorities. *Proceedings of the 88th Annual Meeting of Transportation Research Board*, Washington D.C., 2009, Paper number 09-2817].

The change in heat flow (ΔH) was calculated by subtracting the total heat of fusion for pure water (334 J/g) from the measured heat flow of the characteristic peak. Statistical analysis revealed the following correlation between the DSC data and the SHRP data at 0°C (32°F), as shown in Equation 1:

$$\text{Ice Melting Capacity} = 0.66 \times T + 8.58 \times \text{Log}_{10}(\Delta H) - 4.86 \ (R^2 = 0.91) \qquad \text{Eqn. 1}$$

The positive coefficient associate with $\text{Log}_{10}(\Delta H)$, i.e., 8.58, is consistent with the notion that the more powerful a deicer is, the less external heat it needs to melt the ice (and thus the higher value in ΔH). The high R-square value confirms that there is a strong correlation between the DSC data and the SHRP ice melting capacity at 32°F (0°C). The less-than-one R-square can be attributed to: experimental error especially in the SHRP test, the different behavior between solid and liquid deicers in the SHRP test, etc. As such, DSC may hold the promise of a reliable standard test protocol to assess the deicer performance under certain road weather conditions.

Figures 2.7, 2.8, and 2.9 are DSC thermograms for the liquid deicers Freezeguard CI Plus, NaCl+GLT, and Geomelt C sampled over time, respectively. For each type of deicer, their DSC thermogram was tested at a 2°C/min heating/cooling rate for inhibited solutions.

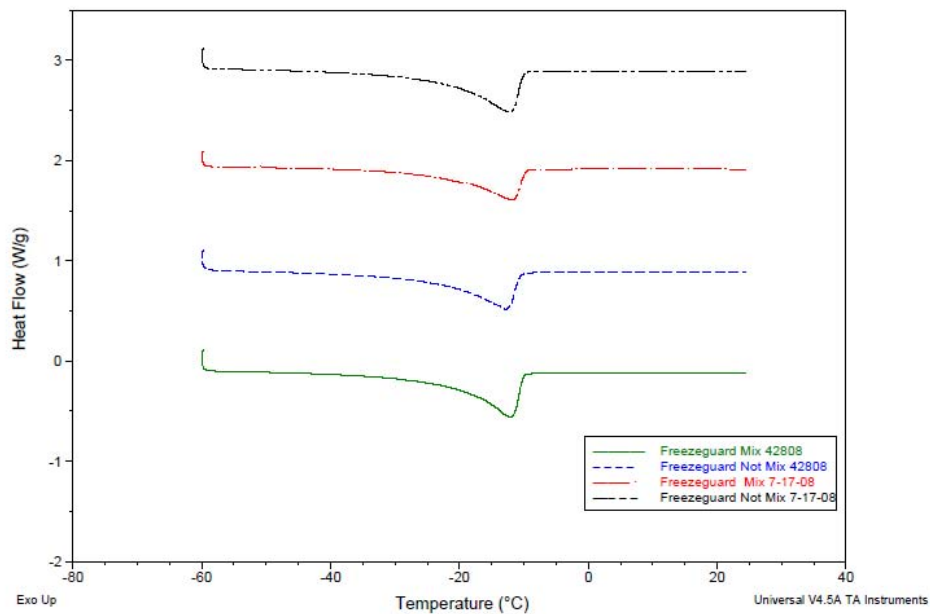Figure 2.7 DSC thermograms of Freezeguard CI Plus over time.

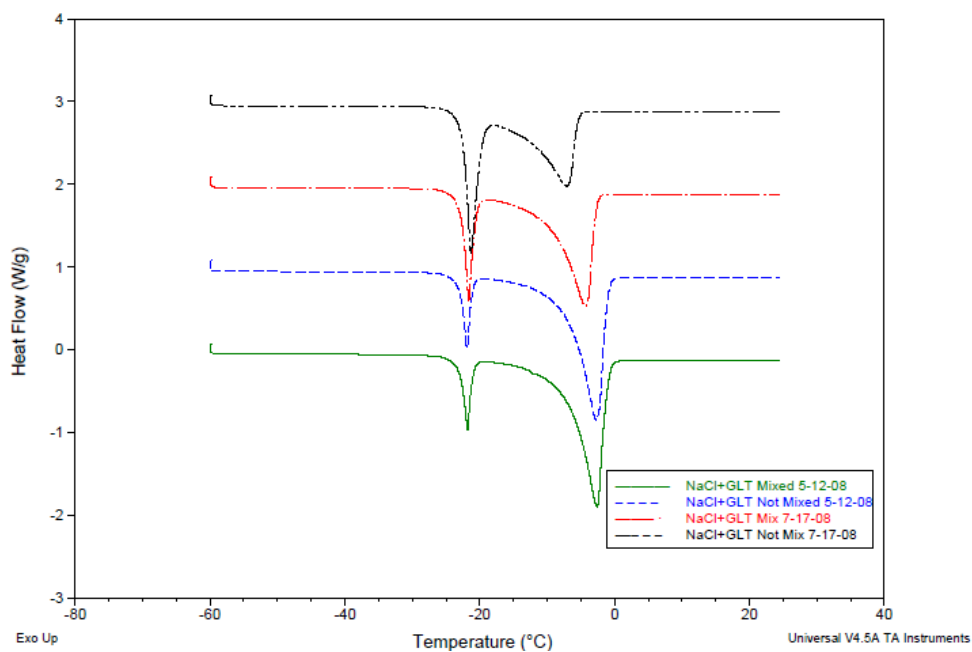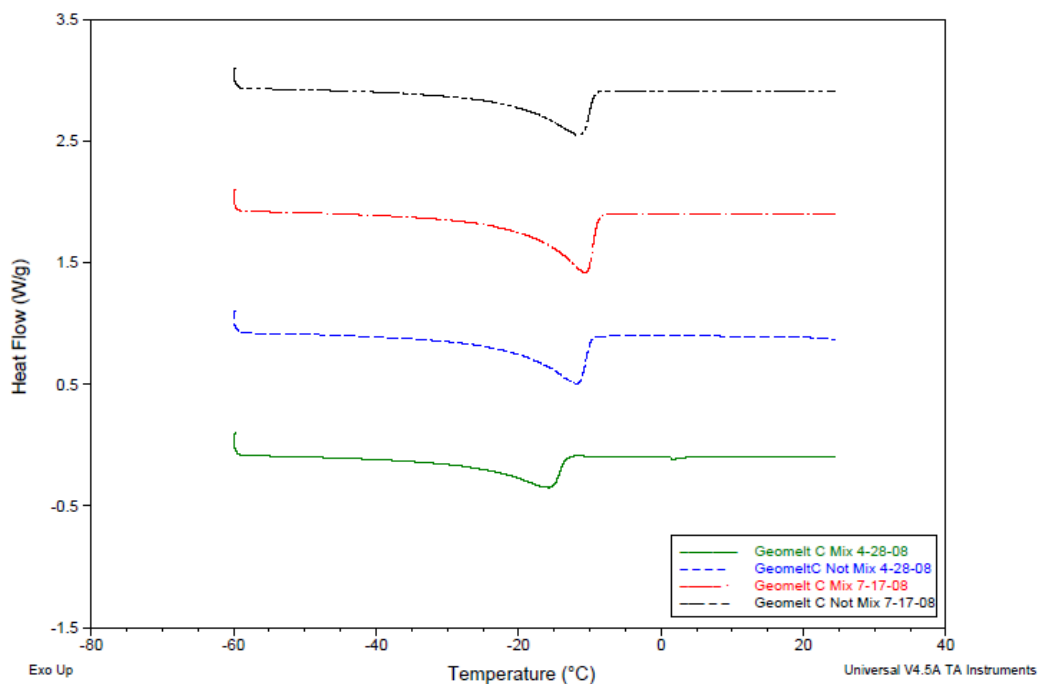Figure 2.8 DSC thermograms of NaCl+GLT over time.

Figure 2.9 DSC thermograms of Geomelt C over time.

Task 2.4.: Inhibitory Longevity under Laboratory Conditions (20%)

Laboratory testing began in December 2008. Ice melting capacity data for the liquid deicers was collected at 30 min, 60 min, and 90 min for a temperature range of 25 to 32°F. Test results showed that the greatest amount of ice was melted in the first 30 min, then the ice melting capacity rate decreased through 90 min. Based on these results we feel confident that the field sampling for the liquid products can be conducted at 30 min intervals for up to 90 min and will yield enough liquid for laboratory testing.

The lab testing to determine the best way to remove deicer and melted ice/snow from the petri dishes and asphalt pucks is currently underway at the MSU Sub-zero Sci. & Eng. Facility. Test results have shown that suction of material off the asphalt pucks, especially in the case of the black ice event, is not feasible, and for this reason we have decided to focus our collection method on petri dish collection of materials. Preliminary results have shown high recovery rates of applied material from this method. We are waiting on lab results to provide data on chloride and inhibitor concentrations from the recovered material.

Task 3: Field Investigation (25%)

Task 3.1.: Inhibitor Longevity: Storage Monitoring

Deicer Corrosion Inhibitor Concentration

The UV-vis standard curves have been developed for the liquid deicers which allow us to quickly determine the corrosion inhibitor concentration over time (Figure 2.2). UV-vis data showing corrosion inhibitor concentration from field samples is presented below in Figures 3.1, 3.2, and 3.3. The figures show that mixed and not-mixed liquid deicers can have different corrosion inhibitor concentrations for the same deicer, but at this point the difference between mixed and not mixed corrosion inhibitor concentration of the samples is not statistically significant. The data also show that the not-mixed samples generally have higher corrosion inhibitor concentrations.

Figure 3.1 Geomelt C UV-vis data showing the corrosion inhibitor concentration from collected field samples.
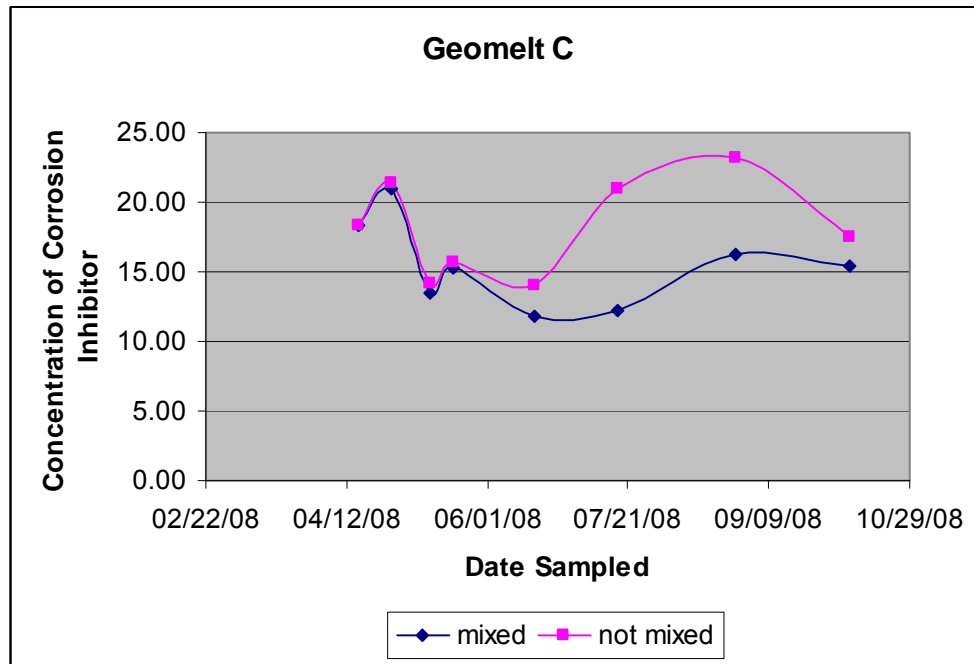

Figure 3.2 Freezeguard CI Plus UV-vis data showing the corrosion inhibitor concentration from collected field samples.
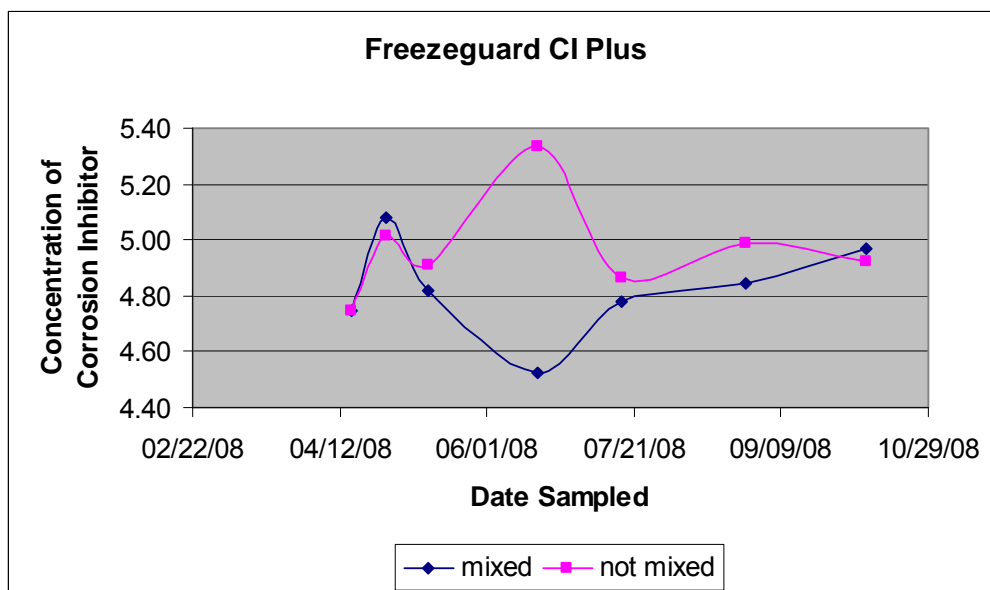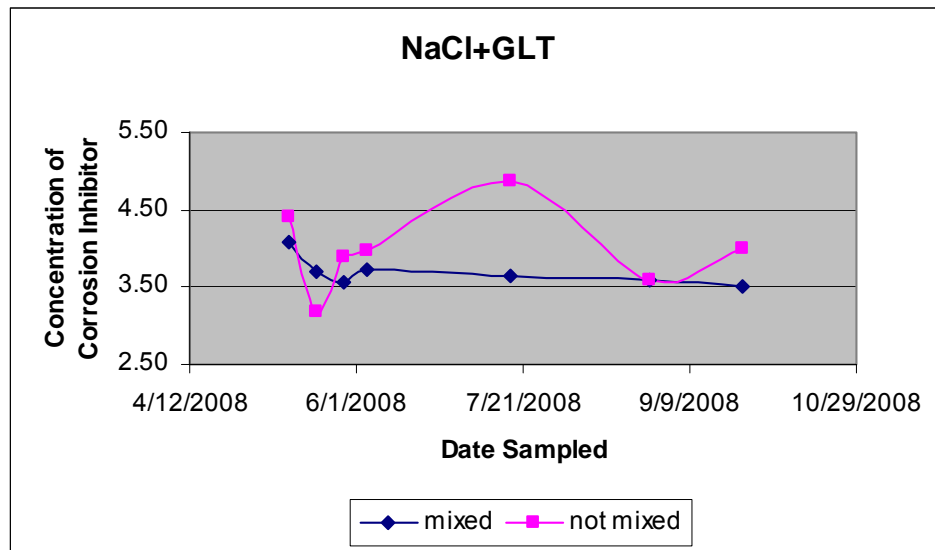
Figure 3.3 NaCl+GLT UV-vis data showing the corrosion inhibitor concentration from collected field samples.

Deicer Chloride Concentration

The chloride concentrations of the liquid deicers over time show a similar trend, where the not-mixed samples tend to have higher chloride concentrations than the mixed samples. This is most likely due to stratification within the holding tanks and has been captured because all samples were collected from the bottom of the tanks. To further investigate this phenomenon we sampled each tank at three depths; bottom, middle, and top, in November 2008 and will continue to monitor the tanks this way over time. Please note that the chloride concentration of each deicer sample was not based on one single measurement of the as-received deicer sample, but rather based on chloride sensor measurement of multiple diluted samples and subsequent extrapolation (which minimizes the measuring error in the data).

Figure 3.4 Percent corrosion rate of deicers as compared to the ratio of the corrosion inhibitor concentration divided by the chloride concentration for each deicer.
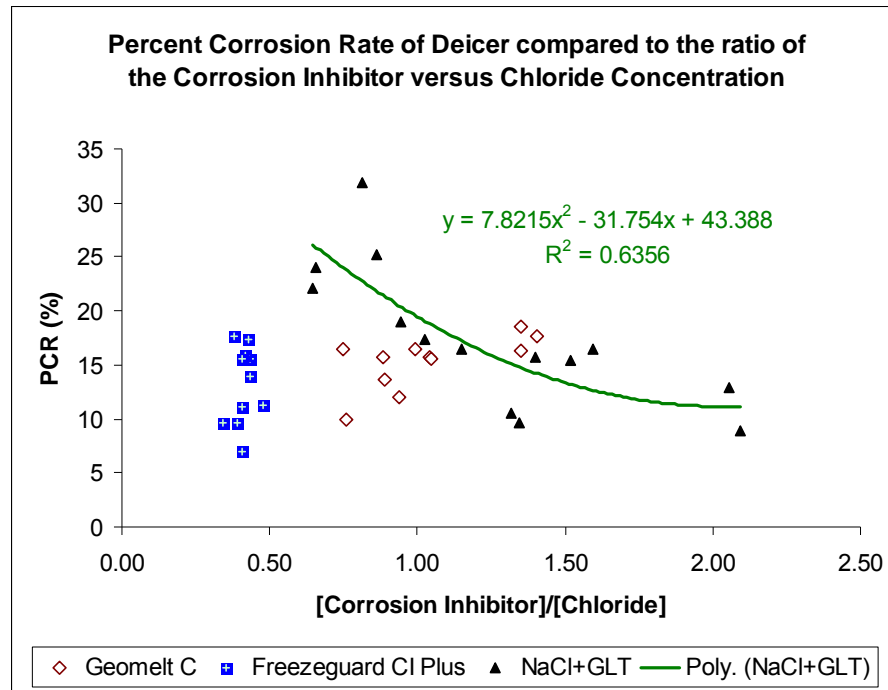
Further analysis of the data reveals potential correlations between the percent corrosion rate (PCR) and the deicers corrosion inhibitor and chloride concentrations. For NaCl+GLT, as shown in Figure 3.4, there is a strong correlation between the PCR and the relative ratio of inhibitor-to-chloride, with R-square of 0.6356. As the inhibitor-to-chloride ratio increases, the PCR decreases. Such a clear correlation does not exist for the other two deicers.

Nonetheless, we identified the following strong correlation for Geomelt:

$PCR = 207.85 + 13.67[Cl^-] - 11.60[Inhibitor] + 190.90[Inhibitor]/[Cl^-]$ ($R^2 = 0.72$)

Regression Statistics	
Multiple R	0.850350762
R Square	**0.723096419**
Adjusted R Square	0.604423456
Standard Error	1.571039746
Observations	11

ANOVA

	df	SS	MS	F	Significance F
Regression	3	45.11698	15.03899	6.093185837	**0.023030201**
Residual	7	17.27716	2.468166		
Total	10	62.39414			

	Coefficients	tandard Err	t Stat	P-value
Intercept	**-207.8510117**	84.27219	-2.466425	0.043057962
[Cl-]	**13.66628755**	5.306559	2.575358	0.036719945
[Inhibitor]	**-11.60558805**	5.012757	-2.315211	0.053772441
[Inhibitor]/[Cl-]	**190.9058751**	79.92321	2.388616	0.048266868

Similarly, we identified the following strong correlation for NaCl+GLT:

$$PCR = 14.38 + 4.03[Cl^-] - 2.82[Inhibitor] \quad (R^2 = 0.61)$$

Regression Statistics	
Multiple R	0.779336671
R Square	**0.607365646**
Adjusted R Square	0.535977582
Standard Error	4.418233006
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	2	332.1634516	166.0817258	8.5079439	**0.005847**
Residual	11	214.7286118	19.52078289		
Total	13	546.8920635			

	Coefficients	Standard Error	t Stat	P-value
Intercept	**14.3794204**	11.85048549	1.213403486	0.2503877
[Cl-]	**4.03416342**	1.010433699	3.992506804	0.0021131
[Inhibitor]	**-2.822740399**	2.914690827	-0.968452768	0.35363

Freezeguard CI Plus shows little to no correlation between the PCR values and the inhibitor and chloride concentrations. As more data is processed we expect these correlations to hold or become stronger.

The last product, IceSlicer Elite, was delivered in December 2008 and has been placed on the inside and outside pads at the field site. A sample of the IceSlicer Elite was collected

on the day of delivery and sent to Mr. Ron Wright at Idaho Transportation Department for preliminary testing.

Problems Encountered

Preliminary testing of chloride concentration and PCR was conducted by Mr. Ron Wright for each deicer collected from the original shipment. The chloride concentration data Ron collected for NaCl+GLT showed a brine concentration of 18.5%, instead of the targeted 23%. After discussing this issue with the Steering Committee it has been decided that we will add additional salt to the two NaCl+GLT tanks and mix them to bring them up to a 23% brine solution. Prior to adding the additional salt a second stratified sampling of both tanks will be conducted to determine the extent of stratification with in the tanks prior to the modification.

Task 3.2.: Inhibitor Longevity and Deicer Performance: Field Operational Tests

In the 2008-2009 winter season, the field operational tests will be conducted on a 200 x 600 ft pad of 2-inch asphalt overlay at *Transcend*. The test sections will be marked with reflective lane markers (5/16in x 48in). There will be six test sections-one for each deicing product and one control. The buffer zone between each 12 ft wide test section is 18 ft wide, sufficient to prevent cross contamination between the test sections.

Four Turbo Crystal snow guns will be used to create the specified storms over this area. Testing of the snow guns and water system will occur in early to mid February 2009. More details are being planned in the format of SOPs as described earlier.

The liquid and solid application trailer has been built and will be hauled to *Transcend* for field testing. The liquid application system involves four 25 gallon tanks-one for each of the three liquid deicers and a fourth for water to flush the system lines. The liquid deicers will be applied from an adjustable height boom (and boom length of 140 inches) from 13 spray nozzles. The number of spray nozzles is necessary to ensure overlap of the spray and application of the correct quantity of deicer. The application rate range we can achieve is approximately 40-150 gallons per lane mile. The solid material will be applied with a sanders/fertilizer spreader with a capacity of 170 pounds, or 3.6 cubic ft. Field trials will be used to determine the amount of casting necessary for the solid product to evenly cover the test section.

Figures 3.5 and 3.6 show the *Transcend* test facility in summer and winter. One of the many challenges to be faced this winter will be the blowing and drifting snow which can be seen in Figure 3.6 at 2-3ft deep.

Figure 3.5 Arial view of the *Transcend* field test site.

Figure 3.6 Photograph of the field site from December 2008 showing 2-3ft snow drifts.

Task 4: Project Reporting

This is the fourth project quarterly progress report. The next progress report will provide information through mid-April 2009 and will be submitted late April 2009.

Summary of Expenditures

Table 4.1 below summarizes the expenditures on this project through December 31, 2008. $262,784.82 had been spent by December 31, 2008. The Pooled Fund budget requested for 9/29/2008-9/28/09 was $194,252 with the rest funded by the WTI-UTC. The second year budget was still not in place by submission of this progress report.

Table 4.1 Summary of Expenditures by December 31, 2008.

Budget Category	Budget		Spent	Remaining
	Year 1	Year 2		
Labor ($)	$59,509.87	$81,717.00	$91,994.34	$49,232.53
Travel	$2,000.00	$8,100.00	$6,132.48	$3,967.52
Operations/Communications	$400.00	$500.00	$120.02	$779.98
Infrastructure start-up cost	$80,000.00	$3,000.00	$79,460.11	$3,539.89
Contracted Testing Services	$3,500.00	$3,500.00	$2,259.50	$4,740.50
Lewistown Facility Usage	$3,000.00	$30,000.00	$0.00	$33,000.00
Corrosion Lab Testing and Other Supplies	$7,000.00	$9,500.00	$4,443.95	$12,056.05
Total Direct Cost	$155,409.87	$136,317.00	$184,410.40	$107,316.47
Indirect (42.5%)	$66,049.19	$57,934.73	$78,374.42	$45,609.50
Total Cost ($)	$221,459.06	$194,251.73	$262,784.82	$152,925.97

Project Schedule Summary

Table 4.2 details the updated project timeline, in which the duration of each task is shown by months.

Table 4.2: Project Timeline by Month

Tasks	Milestones	Calendar Year / Month
		2007 10 11 12 — **2008** 1 2 3 4 5 6 7 8 9 10 11 12 — **2009** 1 2 3 4 5 6 7 8 9 10 11 12 — **2010** 1 2 3 4 5 6 7 8 9
Task 0. Project Management		
Project kickoff*	*Oct-07*	
Task 1. Experiment Design and Planning		
Task 2. Laboratory Investigation		
Task 2.1. Methods to Rapidly Quantify Chloride and Inhibitor Concentrations		
Task 2.2. Method to Rapidly Quantify Corrosivity of Deicers		
Task 2.3. Method to Rapidly Quantify Deicer Performance		
Task 2.4. Inhibitor Longevity under Laboratory Conditions		
Task 3. Field Investigation		
Task 3.1. Inhibitor Longevity: Storage Monitoring and Cost-Benefit Analysis		
Task 3.2. Deicer Performance: Field Application		
Task 4. Project Reporting		
Quarterly progress reports	*End of each quarter*	
Draft final report	*Jul-10*	
Final report w/ executive summary	*Sep-10*	

*UTC portion started 8/1/07 and the PNS portion start in Feb. 2008.